LESSON 41 – STEALTH
You don't need all that countermeasures stuff if they can't find you!

Reading:
Stimson **Ch. 39, Ch. 42**
Stealth Handout
Review lessons 35-41, Review lessons 1-34
Problems/Questions:
Work On Problem Set 5
Objectives:
41-1 Understand how stealth technology uses EM wave redirection.
41-2 Understand how stealth technology uses EM wave absorption.
41-3 Understand the basic principles of Low Probability of Intercept (LPI) technology.

Last Time: IR Missiles
Employment
Design
Solid-State Seekers
IRCM/IRCCM/IRCCCM…

Today:

NOTE: All of today's discussion about stealth is just guesses. But how did I come up with these guesses? A knowledge of BASIC physics!

Show corner cube, and show two mirrors arranged perpendicularly to each other (∟). How does this relate to stealth?

Note that the B-2 and B-117 both carry corner cubes as standard equipment. When operating in non-stealth mode, they use lights and lower the cubes into the air stream so that ATC and other aircraft can find them. However, when it's time to button up for combat, the lights go off and the cubes are retracted, kind of a "cloak-on" maneuver.

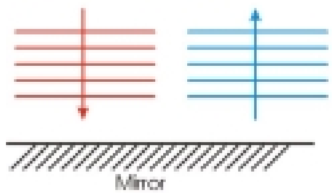
Handout current stealth articles from AW&ST, etc., as examples of current stealth research.

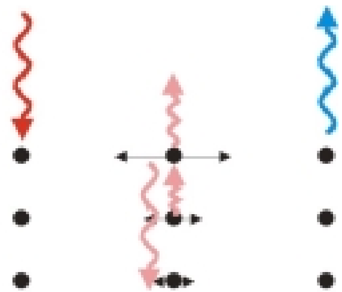
Take a few minutes to let the cadets read it, and then discuss the stealth aspects of the jet. How does the F-35 (JSF) differ from the B-117?

Discuss reflection of radar waves as the first major thrust of stealth research.

How does reflection work?

A passing wave excites oscillations in electrons (why not protons?). Conservation of energy says that since the electron's energy of motion comes out of the wave's energy, then the wave is damped. This is why the wave doesn't penetrate very far into matter, especially conductors where the electrons are free to move relatively long distances.



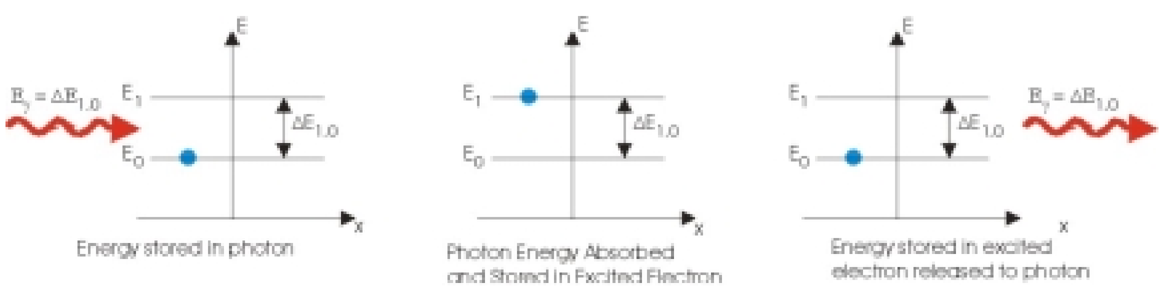


Maxwell's equations say an electromagnetic wave interacting with matter leads to an oscillating electron which leads to another electromagnetic wave.

Show Mechanical Universe 40:33896.

This shows how <u>waves</u> interact with matter. But is light really a wave? What if it acts like a particle? Discuss radar photons.

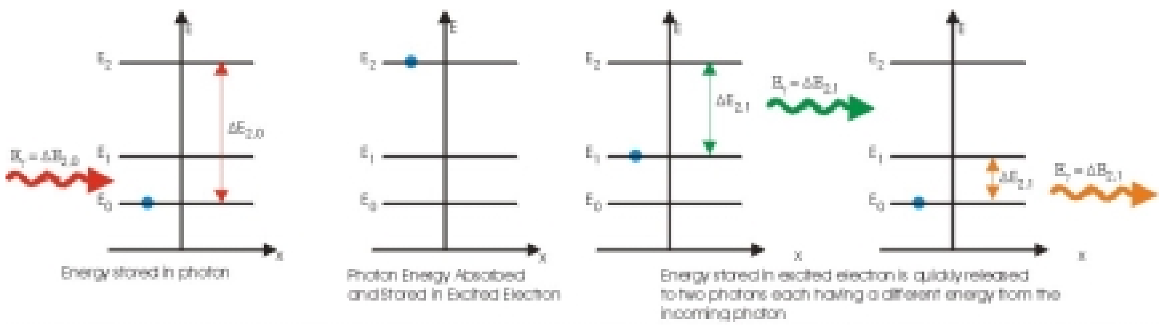
Let's say we have a two-level atom with its valence electron in the ground state. What happens if a photon of $E_\gamma = \Delta E_{0,1}$ comes cruising by? There's a probability (NOT a certainty) that the photon will be absorbed. Once it's in the excited state, it wants to decay back to the ground state, but it waits for a while.



The AVERAGE time one of these electrons stays in the excited state is called the lifetime of the transition, τ. Some electrons stay longer, some shorter. But on average, they all stay for τ.

When the electron decays, energy must be conserved., so a photon of energy $E_\gamma = \Delta E_{1,0}$ must be given off.

But what if we have a three-level system? If a photon of energy comes along, the electron gets excited to the second excited state. What happens next depends upon the relative lifetimes of $\tau_{2,1}$ and $\tau_{2,0}$. If $\tau_{2,1} << \tau_{2,0}$ then almost all of the electrons will emit a photon of energy $E_\gamma = \Delta E_{2,1}$ and then will emit another photon of energy $E_\gamma = \Delta E_{2,1}$. What Doppler shifts do we typically look for? From our rules of thumb from a few lessons back, we usually try to see shifts on the order of 100kHz in a 10GHz signal, or ±1/100,000 of the total energy (remember that energies and frequencies are directly proportional). This says that if the energy difference between the second and first levels are greater than (100kHz)*h, the photon re-radiated by the three-level material won't be detected by the threat radar.



This absorption-re-radiation out of band is the second major thrust of stealth research.

The last bit of stealth is completely different, and we've discussed a lot of it previously. Part of not being seen is not being heard. We need to ensure that we do not emit anything that might give us away. If we have to emit, it needs to be a signal that has a low probability of interception (LPI) by anyone who isn't supposed to hear it. In radar design, this means using long coherent integration times and small amplitude signals, using highly frequency agile designs, or not transmitting at all and using someone else's eyes (JTIDS, etc.). It also means doing everything possible to reduce other EM signatures, primarily IR, as well.

Show Coherent.avi as an example of below-noise-level signals being detectable through coherent integration.

Next lesson will be a comprehensive review for the final. Come prepared with questions!